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Destruction Limits of Aluminum and Boron Carbide Targets

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Subject: Destruction Limits of Aluminum and Boron Carbide Targets.

1. Introduction.

When the flip targets are used for beam cleanup, they will typically intercept only a small fraction of the beam, say less than 10%, but may be required to do this in an essentially 'steady state' condition. On the other hand, when used for beam size measurements as in refernce 1, the fraction intercepted by the target may approach 100%, but need only be done for a few pulses at a time, with time for cooldown between measurements.

The present aluminum targets, shown in Figure 1, have a blade .375" wide and .125" thick where it hits the beam. Past experience has shown that the intensities in the AGS are sufficient to destroy these targets, simply because targets have been found either melted off or notched where the beam hits them. Unfortunately, it was never known just what the threshold for the destruction was. In gathering the data for reference 1, the target withstood losses of 44% for about 90 consecutive pulses, and losses of >80% for fewer than ten pulses, at an intensity of 6 TP.

A test target was made using boron carbide, which has a very high melting temperature. Unfortunately, boron carbide has lower thermal conductivity than aluminum, so the heat from the leading edge of the target, where the energy loss occurs as the target flips into the beam, will not be conducted away as well, and the localized temperature rise will be higher.

The test target consists of a bar of boron carbide held in an aluminum holder, as in figure 1. The target flipping mechanism flips the target around the axis to an 'upright' position against a stop. When the parameters which control the flipping are not proper, the target bangs hard against the stop, which is not very friendly for a brittle material like boron carbide. S. Naase found that the original boron carbide target, which was the same overall length as the aluminum targets and thus stuck out about 2.625" past the holder, was so fragile as to be unusable, while a very short target, sticking out about 1.5" past the holder, could survive anything the drive mechanism could deliver.

The target used here was made just long enough to reach to the center of the beam, with an extra .25" to be sure. This target will probably break if driven with very wrong parameters. Before it was put into the ring, S. Naase determined a good set of parameters for it which brought it to the upright position, and back down, in a short time with minimal bouncing and banging. Then it was mounted in the J05-outer position, and unplugged from the drive so it would not be used inadvertently and possibly broken before this test.

The target at J05-inner was a standard aluminum target.

2. The Test.

The AGS was operating with SBE at 592 msec, and FEB at 681 msec, with an intensity of 12-13 TP for FEB. We wanted to flip the target late in the AGS cycle to make the test as severe as possible. At high energy, the beam spot is smaller, and the protons deposit more energy in the target before they are lost from the beam. Thus we chose a time of approximately 630 msec for the target beam loss, between SBE and FEB. It was important that the loss be before the H5 bump comes on. Otherwise the protons which have multiple scattered in a few passes through the target, but are not yet completely stopped, may hit the H5 kicker, which not only may damage the kicker, but also invalidates the test because the target is relieved of some of its heat load. We could have gotten 12/11 more intensity by turning off SBE, but we didn't.

The target drive was driven into the beam until the loss just reached 100%. Note that if the target had been driven in past this point, the test might be less sensitive since the target could still cause total beam loss even with part of its leading edge melted away.

After being set up, the target was turned off and allowed to cool so the destructive test would start from 'cold'. Then the target flipping was turned on and the pulses counted until something happened to the target, as evidenced by the failure to get 100% beam loss.

The results are as follows:

Beam: 12-13 TP per pulse, 1.4 sec rep rate, approx 26 GeV/c.

Aluminum: Failed after 18 pulses.

Boron carbide: No change after 300 pulses, test halted.

3. Postmortem.

A piece of the aluminum target about one inch long has been melted off and is lying in the vacuum box. The boron carbide looks undamaged. It has a slightly greyish area on the leading edge where it hit the center of the beam.

The radiation levels are posted as (in mr/hr at 12") J05=1500, J06=500, J07=250. For comparison, H10=750 (FEB), G15=600 (ferrite quad), F10=2000 (SEB), E20=15000 (catcher), and lots of areas are at 200.

4. Conclusion.

A target made of boron carbide would allow beam cleanup or size measurements without fear of damaging the target (at least up to 13 TP). The present boron carbide target is not sturdy enough mechanically to survive the present flipping mechanism without using extreme care. A design similar to this test target, but with the blade wider or triangular-shaped (wider at the base) should be strong enough to survive any 'banging' that the target motor can give.

For the longer term, it would be nice to have targets which flip on an axis perpendicular to the present axis, so setting their position is decoupled from the flipping motion, but that will require a lot of design and construction,

Parameters.

In case anyone wishes to use the present boron carbide target, here are the function generator parameters which drive it gently so it will not break:

TIME	120	180	205	605	645	685
AMPLITUDE	450	-300	180	-550	220	-40
DURATION	60	25	400	40	40	999
SET WITH	AU	BU	HU	AD	BD	HD

Reference.

1. R. Thern, AGS Studies Report No. 179, Measurement of circulating beam size with flip target.

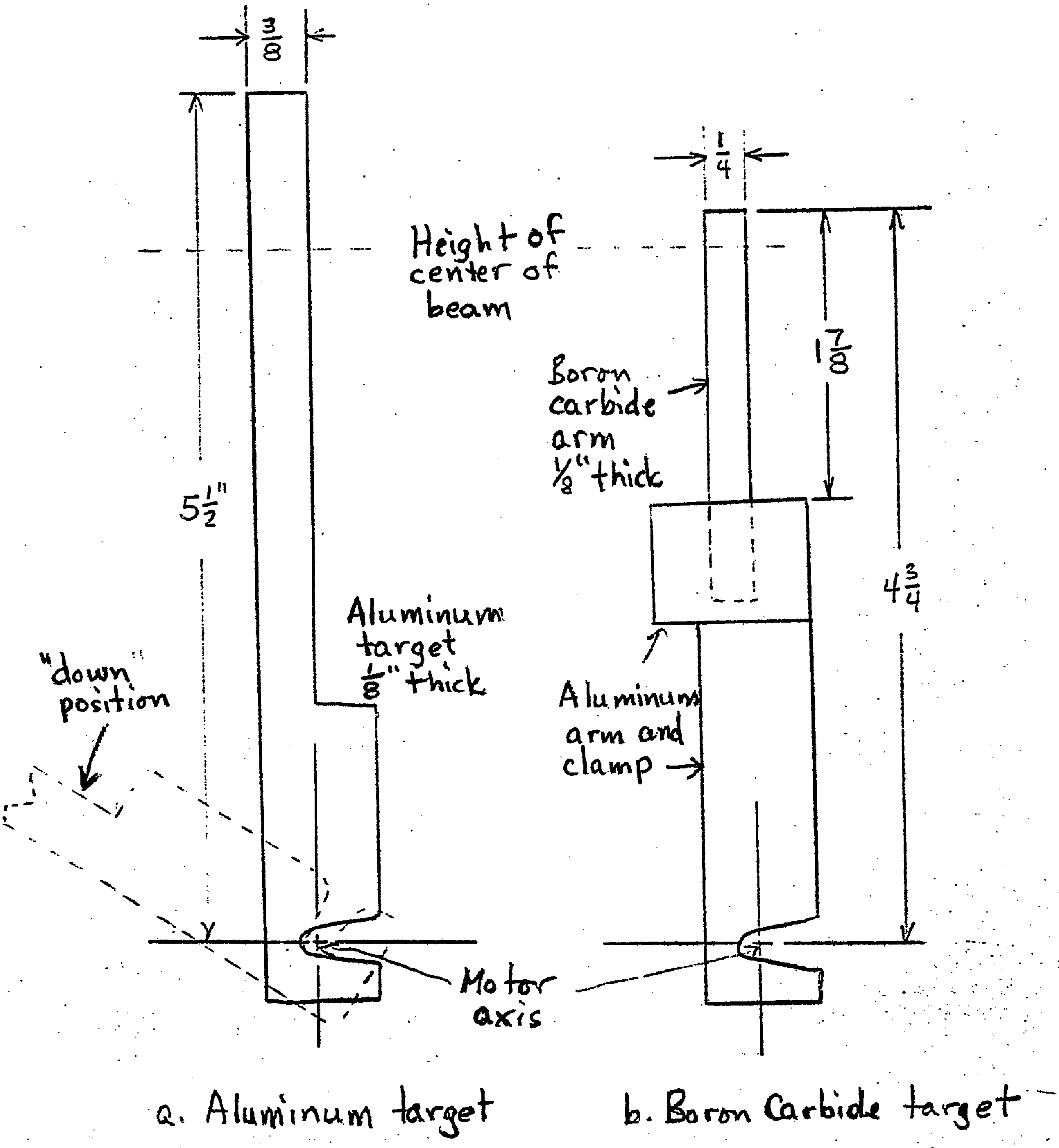

Figure 1. Targets